PROGRAM OF FELLOWSHIP WORK

The process of evolution was analyzed by Darwin into three factors: variation, heredity, and survival. It was to account for differential survival that the theory of natural selection was brought forward. Darwin realized that further progress in the understanding of evolution depended on the study of variation and heredity, and he collected a large mass of data bearing on these subjects. This disclosed a great deal about the kinds of variations that occur and something about their inheritance. The statistical method of the study of heredity, which was developed later by Galton, made a more precise analysis but did not reveal the biological facts concerned with the hereditary mechanism.

In the meantime the principles of heredity had actually been discovered. Mendel, who had begun the study of the problem in 1857, published his results in 1865, several years after the appearance of the *Origin of Species*. The application of Mendel's laws might have explained many of the phenomena of heredity then known; but strangely enough these laws lay unnoticed for thirty-five years. During this time the behavior of the chromosomes in the formation of the germ cells was worked out. We now have evidence that the chromosomes carry the Mendelian factors and furnish the mechanism of inheritance. But it was not until after the re-discovery of Mendel's paper in 1900 that this relation between chromosomes and heredity factors was pointed out (Correns, Boveri, Sutton), or that the determination of sex was brought into line with Mendelism (Strasburger) and chromosome distribution (McClung, Stevens, Wilson).

The correlation between chromosomes and genes has led to great progress in the theory of heredity. This has been due largely to the work of Morgan, Sturtevant, Muller and Bridges on *Drosophila melanogaster*. In this form it has been shown that there are four groups of factors corresponding to the four pairs of chromosomes; that within each chromosome the factors are arranged in linear series; and that in the formation of the germ cells, crossing over occurs between homologous chromosomes so that entire sections of these are interchanged. The behavior of the chromosomes has been studied by an analysis of the phenomena of crossing over, especially of

"coincidence" (the influence of crossing over in one region of a chromosome on crossing over in other regions), and by the investigation of anomalous distributions of chromosomes, such as non-disjunction and triploidy. Moreover, numerous mutations have been observed and a preliminary measurement of the rate of mutation has been made.

The evidence so far obtained indicates, therefore, where genes are located and how they are distributed. But as to the nature of the gene we are still in the dark. Nor do we know what physiological processes are involved in the behavior of the chromosomes, in the interaction of genes with each other and with their environment to produce somatic characters, or in the changes in the nature of genes which we call mutations and which are the basis of evolution. Of course any solution of these problems must be, in the last analysis, physico-chemical; and unfortunately our knowledge of the physics and chemistry of living matter is not sufficient to enable us to proceed directly to a complete solution. We can, however, throw a good deal of light on the problem of using what tools we have at hand, for it should be possible by varying the conditions (genetic and environmental) to arrive at some notion of the processes involved and the nature of the genetic material.

I have planned my work on the Sigma Xi foundation with a view to contributing toward the solution of the following problems:

(1) Rate of mutation in *Drosophila virilis.* A study of this will furnish a measure of the mutation rate and will allow a comparison with the rate in *D. melanogaster.*

(2) Crossing over and "coincidence" in *Drosophila virilis.* The phenomenon of "coincidence of crossing over" furnishes crucial evidence on the theory of linear linkage. I have made a study of "coincidence" in *D. melanogaster* and have pointed out the bearing of the results on the interpretation of the behavior of the chromosomes, and I am investigating this phenomenon in *D. virilis* with the same end in view.

(3) Non-disjunction in *Drosophila virilis.* Non-disjunction is a failure of the genes to segregate as they normally do. This appears at first sight an exception to the chromosome theory, but cytological evidence shows that the exceptional distribution of the genes is paralleled by the distribution of the chromosomes, so that direct

proof of the theory is afforded. I have observed both primary and secondary non-disjunction in *D. virilis* and I have planned a further analysis of these phenomena.

Experiments have been planned so that data bearing on these three problems may be obtained simultaneously.

Of course in work of this kind unexpected phenomena may occur, and the investigation of such phenomena may lead to work on problems other than those outlined.

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